CLAIMS

1. An ultrasound treatment system comprising:

an ultrasonic probe comprising an ultrasound therapy transducer adapted to non-invasively apply ultrasonic therapy to tissue;

a switch-mode amplifier design comprising at least one switch-mode amplifier semiconductor;

a switch-mode amplifier circuit configured to generate digital waveforms to drive the switch-mode amplifier semiconductor to drive the ultrasound therapy transducer; and

an electrical power system configured to provide electrical power to the ultrasound therapy transducer, the electrical power system comprising a power amplifier device and a circuit;

in which the power amplifier device comprises at least one semiconductor transistor,

in which the at least one semiconductor transistor is a field effect transistor,

in which the field effect transistor is configured to operate with an efficiency of at least 75% at a radio frequency (RF) in a range between 200 kHz and 20 MHz.

2. A system according to Claim 1, in which semiconductor transistor comprises a III-V compound.

3. A system according to Claim 1, in which semiconductor transistor comprises Gallium Nitride (GaN).

4. A system according to Claim 1,

in which the power amplifier device comprises:

a switch-mode amplifier design comprising the field effect transistor; and

a circuit configured to generate digital waveforms to drive a plurality of gates of the field effect transistor to drive a piezoelectric ultrasound transducer;

in which the circuit comprises four transistors configured in an H-bridge configuration.

5. A system according to Claim 1,

in which the power amplifier device comprises:

a switch-mode amplifier design comprising at least one field effect transistor; and

a circuit configured to generate digital waveforms to drive a plurality of gates of the field effect transistor to drive a piezoelectric ultrasound transducer;

in which a signal driving the field effect transistor is configured to compare an output of a sinusoidal direct digital synthesis circuit to a DC voltage;

in which an output power is in the range from 0.1 W to 200 W;

in which the circuit comprises four transistors configured in an H-bridge configuration.

6. A system according to Claim 1,

in which the semiconductor is gallium nitride,

in which power amplifier device comprises:

a switch-mode amplifier design comprising at least one gallium nitride field effect transistor, in which each gallium nitride field effect transistor comprises a plurality of gates; and

a circuit configured to generate digital waveforms to drive the plurality of gates of the gallium nitride field effect transistors to drive the ultrasound therapy transducer, in which the ultrasound therapy transducer is a piezoelectric ultrasound transducer;

in which a signal driving the field effect transistor is configured to compare an output of a sinusoidal direct digital synthesis circuit to a DC voltage;

in which an output power is in the range from 0.1 W to 200 W;

in which the circuit comprises four gallium nitride transistors configured in an H-bridge configuration;

in which a gate drive signal has a variable duty cycle that is used to control a harmonic content and a power in the output signal;

further comprising a power amplifier converter which supplies power to a radio frequency output signal power with an efficiency greater than 75%;

in which a supply voltage to the power amplifier is modulated using a switch-mode DC-DC converter that reduces a fixed high voltage input to a lower supply voltage;

comprising two or more power amplifiers, in which a single power amplifier is configured to drive at a single piezoelectric transduction element of the ultrasound therapy transducer, in which the ultrasound therapy transducer is a high-intensity focused ultrasound transducer;

in which the power amplifier is configured to drive output at two or more different amplitudes;

in which the power amplifier is configured to drive output at two or more different phases;

in which a phase and a frequency are controlled by a direct digital synthesizer;

in which the system is configured to drive transducers with an impedance in the range from 20 ohms to 120 ohms and a phase angle from +45 degrees to -45 degrees.

7. A system according to Claim 1, in which power amplifier device comprises:

a switch-mode amplifier design comprising at least one switch-mode amplifier semiconductor; and

a switch-mode amplifier circuit configured to generate digital waveforms to drive the switch-mode amplifier semiconductor to drive the ultrasound therapy transducer.

8. A system according to Claim 1, in which a signal driving the field effect transistor is configured to compare an output of a sinusoidal direct digital synthesis circuit to a DC voltage.

9. A system according to Claim 1, in which an output power is in the range from 0.1 W to 200 W.

10. A system according to Claim 1, in which an output power is in the range from 5 W to 50 W.

11. A system according to Claim 1, in which the circuit comprises four transistors configured in an H-bridge configuration.

12. A system according to any of Claims 1 to 3 and 7 to 11, in which the circuit comprises two transistors configured in a half bridge configuration.

13. A system according to any of Claims 1 to 3 and 7 to 11, in which a gate drive signal has a variable duty cycle that is used to control a harmonic content and a power in an output signal.

14. A system according to any of Claims 1 to 3 and 7 to 11, in which a power amplifier converter supplies power to a radio frequency output signal power with an efficiency greater than 75%.

15. A system according to any of Claims 1 to 3 and 7 to 11, in which a supply voltage to the power amplifier is modulated using a switch-mode DC-DC converter that reduces a fixed high voltage input to a lower supply voltage.

16. A system according to any of Claims 1 to 3 and 7 to 11, comprising two or more power amplifiers, in which a single power amplifier is configured to drive the ultrasound therapy transducer, in which the ultrasound therapy transducer comprises a single piezoelectric transduction element, in which the ultrasound therapy transducer is a high-intensity focused ultrasound transducer.

17. A system according to any of Claims 1 to 3 and 7 to 11, in which the ultrasound therapy transducer is a high-intensity focused ultrasound transducer that is configured for driving by a second power amplifier.

18. A system according to any of Claims 1 to 3 and 7 to 11, in which the power amplifier is configured to drive output at two or more different amplitudes.

19. A system according to any of Claims 1 to 3 and 7 to 11, in which the power amplifier is configured to drive output at two or more different phases.

20. A system according to any of Claims 1 to 3 and 7 to 11, in which the power amplifier is configured to drive output at two or more different frequencies.

21. A system according to any of Claims 1 to 3 and 7 to 11, in which a phase and a frequency are controlled by a direct digital synthesizer.

22. A system according to any of Claims 1 to 3 and 7 to 11, configured to drive transducers with an impedance in the range from 20 ohms to 120 ohms and a phase angle from +45 degrees to -45 degrees.

23. An ultrasound treatment system comprising:

an ultrasonic probe comprising an ultrasound therapy transducer adapted to non-invasively apply ultrasonic therapy to tissue;

a switch-mode amplifier design comprising at least one switch-mode amplifier semiconductor;

a switch-mode amplifier circuit configured to generate digital waveforms to drive the switch-mode amplifier semiconductor to drive the ultrasound therapy transducer; and

an electrical power system configured to provide electrical power to the ultrasound therapy transducer, the electrical power system comprising a power amplifier device and a circuit;

in which the power amplifier device comprises at least one III-V semiconductor power transistor configured to operate with an efficiency of at least 75% at a radio frequency (RF) in a range between 200 kHz and 20 MHz.

24. A system according to Claim 23, in which the at least one III-V semiconductor power transistor is selected from the group consisting of: GaN, GaAs, GaSb, InP, InAs, InSb, InGaAs, AlSb, AlGaAs, and AlGaN.

25. A system according to Claim 23, in which the at least one III-V semiconductor power transistor is Gallium Nitride.

26. A system according to Claim 23, in which the at least one III-V semiconductor power transistor is not one of GaN, GaAs, GaSb, InP, InAs, InSb, InGaAs, AlSb, AlGaAs, and AlGaN.

27. A system according to Claim 23, in which power amplifier device comprises:

a switch-mode amplifier design comprising a plurality of III-V semiconductor power transistors; and

a switch-mode amplifier circuit configured to generate digital waveforms to drive the plurality of III-V semiconductor power transistors to drive a piezoelectric ultrasound transducer.

28. A system according to Claim 23, in which a signal driving the power transistor is configured to compare the output of a sinusoidal direct digital synthesis circuit to a DC voltage.

29. A system according to Claim 23, in which an output power is in the range from 0.1 W to 200 W.

30. A system according to Claim 23, in which an output power is in the range from 5 W to 50 W.

31. A system according to any of Claims 23 to 30, in which the circuit comprises four power transistors configured in an H-bridge configuration.

32. A system according to any of Claims 23 to 30, in which a gate drive signal has a variable duty cycle that is used to control a harmonic content and a power in the output signal.

33. A system according to any of Claims 23 to 30, further comprising a power amplifier converter which supplies power to a radio frequency output signal power with an efficiency greater than 75%.

34. A system according to any of Claims 23 to 30, in which a supply voltage to the power amplifier is modulated using a switch-mode DC-DC converter that reduces a fixed high voltage input to a lower supply voltage.

35. A system according to any of Claims 23 to 30, comprising two or more power amplifiers, in which a single power amplifier is configured to drive the ultrasound therapy transducer, in which the ultrasound therapy transducer is a single piezoelectric transduction element of a high-intensity focused ultrasound transducer.

36. A system according to any of Claims 23 to 30, in which the power amplifier is configured to drive output at two or more different amplitudes.

37. A system according to any of Claims 23 to 30, in which the power amplifier is configured to drive output at two or more different phases.

38. A system according to any of Claims 23 to 30, in which a phase and a frequency are controlled by a direct digital synthesizer.

39. A system according to any of Claims 23 to 30, configured to drive transducers with an impedance in the range from 20 ohms to 120 ohms and a phase angle from +45 degrees to -45 degrees.